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ABSTRACT

This report describes a study to review and interpret existing trend data on vocational education enrollments and teachers. In the first section purposes of the study, research questions, and methodology are defined. Section 2 presents documented historical and projected trend data on vocational education enrollments and staff, together with factors assumed to be influencing changes in vocational trends. These factors include demography, availability of staff, costs of vocational education, and available funds. Section 3 describes a vocational teacher supply/demand (VTSD) model, a system dynamics model which is explicitly casual but the structure of which is guided but not determined by historically observed relationships. (The model produces data paralleling historical trends in vocational education, but it allows the reader to understand the assumptions which produce the trend data.) These incomplete and tentative conclusions are summarized from the model output from the initial base run of the VTSD model: gradual end by the mid 1980s of rising numbers of secondary vocational enrollment, gradual decline in growth at the postsecondary level, and no serious shortages of vocational instructors into the next decade. (Twenty-two tables of trend data and 11 figures depicting model output are provided.) (YLB)

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SUPPLY/DEMAND OF VOCATIONAL EDUCATORS

Final Report

Prepared for
National Institute of Education

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School of Education

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August 1, 1981

Contract:
NIE-Q-81-0073

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Preface

This study is undertaken pursuant to contract NIE-Q-81-0073. The contract calls for a 40 - 60 page Final Report describing the projected supply and demand for vocational education teachers by level of education. The contract also stipulates that a preliminary report be prepared and submitted prior to the completion of the Final Report. The preliminary report was submitted June 22, 1981.

The Final Report is presented below in three sections. The first section (1.0, Background) defines the purposes of the study, research questions and methodology. Subsequent sections describe trends in vocational education (Section 2.0), and the Vocational Teacher Supply/Demand Model (VTSDM) (Section 3.0). Technical assistance was provided by Dr. Barry M. Richmond, Center for Resource Policy, Dartmouth College, in the design and testing of the VTSD model.

1.0 BACKGROUND

1.1 Purposes of the Study

This study is undertaken to review and interpret existing trend data on vocational education enrollments and teachers. The parameters of study are as follows: (a) trend data are national in scope, and not intended to inform local or state planning; (b) data analysis pertains to numbers of students enrolled in vocational programs and numbers of teachers of vocational programs, and is not intended to address issues of equity, quality or relevance of programs and courses, preparation of instructors or adequacy of teaching; and (c) initial projections of data (Section 2.0) take the form of simple linear extrapolations based on 1970's data provided by the National Center for Educational Statistics, National Center for Research in Vocational Education and other sources. Thus, the initial work is descriptive (i.e., how many students and teachers, at what levels, in what subjects). This descriptive work constitutes the first of two phases of the study. The second phase of the study provides an analysis of the data by using system dynamics modeling to examine trend data under varying conditions (Section 3.0). The purpose of phase two, dynamic modeling, is to test assumptions about (a) the full range of parameters under which the system operates to generate observed trends, and (b) what changes can be expected in those trends given:

(i) assumptions about resource allocations;

(ii) assumptions about the formation of human capital required to effect a change in the numbers of students and teachers in vocational education;

(iii) assumptions about the internal dynamics of the system and various choices of policies.

In effect, phase two is a statement about expected trends, altered by varying assumptions and policy objectives.

1.2 Research Questions

The purposes of the study, as described above, lead to the formulation of certain research questions:

(i) What are the current levels of vocational education enrollments and teachers by subject and sector (secondary-post-secondary) and what are the expected levels, given a continuation of present trends?

(ii) What are the current occupational demands for students prepared in vocational education programs, and what are the expected demands, given a continuation of present trends?

(iii) Under the various conditions below, what changes would be produced in vocational education enrollment and faculty trends?

- increase in job demand above that expected from extrapolated data
- decrease in job demand below that expected from extrapolated data
- increase in allocations of programmatic funds
- decrease in allocations of programmatic funds
- time delays built into the system under any of these conditions

(iv) What are the dynamic responses of the system under the above conditions? For example, if additional demand builds up for programs and faculty, how long will it take the system to respond, given that (a) more courses require more teachers; (b) more teachers require more teachers of teachers; (c) increased demand from jobs also increases the attractiveness of private sector employment for vocational teachers; and (d) resources must be reallocated at several levels.

(v) What are the levels of resource allocation required under the above conditions, i.e., given more, or less, demand than expected based on simple extrapolations, and what shifts (reallocations) will occur and how will those shifts affect other policy objectives?

Implicit in these questions (especially iii, iv and v) is a dynamically operating system with finite resources and at least knowable parameters

which determine flows of people and resources over time. It is assumed that if resources are increased at the federal level to meet demand for vocational education, whether demand is stipulated (i.e., by policy) or represents a real response to job pressures or both, the increase in vocational education funds will represent a decrease in regular education funds. That is, we assume a zero-sum budgeting process in which there will be winners and losers. One of the expected outcomes of more vocational education funds would be some decrease in the numbers of academic, general and special students progressing through the system. These points lead us to a preliminary discussion of modeling.

1.3 The Model

The modeling procedures used in this study differ from the standard approach of point-in-time predictions. Such approaches anticipate constancy in conditions. System dynamics models are explicitly causal, but the structure of the model is guided by but not determined by historically observed relationships. The purpose of the model is to be able to test conditional changes over broad ranges of model parameters and to understand shifts from initial operating points to a position outside of historically observed operating ranges. By implication, and as a starting point, any extrapolation of trend data, consistent with the model's causal structure, means some flow of people and resources through a system which requires time to respond. If the system is to expand vocational enrollments, then it will take time to prepare teachers, hire teachers and adjust a chain of interrelated variables including resource reallocations at both the level of expansion and at the next levels where instructors are being prepared. That in turn sets in motion a second order system which prepares instructors and the faculty required to teach instructors. If the system is to expand at the postsecondary level, that expansion will require expansion below and above that point, i.e., more high schiol graduates must be prepared to enter the postsecondary system -- which in turn calls for more instructors at the high school level, at the postsecondary level to accomodate expansion, and a new cycle of instructor preparation for both levels.

Our approach to applying system dynamics modeling in this study will

be to first illustrate the parameters of model output, given extrapolated demand for vocationally trained high school and postsecondary (two-year) graduates. We will see in some detail what the levels of resource commitments, numbers of teachers and numbers of teachers of teachers would have to be under a scenario of "no surprises". We will then test the model to illustrace what the output of graduates would be if the required resources are not forthcoming (i.e., given decisions to limit the allocation of vocational funds). We will also test the model to estimate the likely outputs of graduates, demand for teachers and teachers of teachers under various assumptions that depart from extrapolated job demand.

For example, one of the likely scenarios for the next 10 year period is the reestablishment of the Selective Service. Given the military draft, what would be the expected effects on the system: (a) some initial delay into postsecondary vocational education programs; (b) some switching of interest from vocational education and into the four-year college track (assuming deferments), (c) some time-delayed build-up of vocational demand (assuming a "GI benefits" policy would provide a stimulus for college participation following military service). These expected effects will be tested in model runs.

1.3.1 The System. The system is defined aggregatively as the public elementary-secondary school system, two-year colleges and four-year colleges and universities. We will not include strictly proprietary schools and institutes, nor will we include adult vocational training. This definition of the system roughly corresponds with the commonly referred to "education system". The model will be parametered with national data on enrollments, teachers and expenditures. We will not in the modeling phase be concerned with system details such as the total numbers of courses and programs. Students and teachers will be in an academic track or a vocational track at each level of the system. Expenditures in the system will be represented by a per pupil cost based on historical and projected data.

The system will include a jobs parameter, aggregated as vocational and academic. The model will not create jobs, however. Job demand will be a function of extrapolated occupational positions seperated by academic and vocational parameters. In short, jobs will be an exogenous variable

but will be adjusted to reflect assumptions of higher or lower demand than expected from linear extrapolation.

1.4 Model Assumptions

Implicit in our definition of the system and model are certain assumptions:

1.4.1 Student Flows

(i) The numbers of students who can enroll in high school vocational programs is some fraction of the total high school population.

(ii) That fraction (of the total high school population) is determined by:

- job demand -- created exogenously and based on occupational projections for employment in jobs calling for vocational and academic preparation
- fraction of students -- enrolling in vocational programs is a function of job prospects, and other factors:
  - (a) job prospects in occupations calling for vocational preparation
  - (b) job prospects in occupations calling for academic preparation
  - (c) capacity considerations: here it is envisioned that teachers/administrators may compete for students if students are in short supply (built in bias will favor the academic track)
  - (d) available resources -- the fraction of students who can be enrolled in vocational programs (regardless of demand) will be determined by resources available (fraction of total expenditure)

(iii) The fraction of high school students entering postsecondary vocational programs will be a fundtion of:

- a fraction of high school students enrolled in secondary vocational education programs; and a fraction of non-vocational students not attending 4 year colleges
- job demand, decisions of students, capacity, and resources (see above)

1.4.2 Vocational Educators

(i) The number of vocational educators required to teach at the secondary and postsecondary levels is some fraction of all educators being prepared by schools of education

(ii) The fraction of high school graduates who seek to be prepared as vocational educators is some fraction of the total college bound population of high school graduates seeking admission to schools of education

(iii) That fraction (of the total college bound population) is determined by

(a) the hire rate for vocational educators (in turn a function of student demand and available resources)

(b) the hire rate modulated by the overall effects of the hire rate of all educators -- assumes that if all educators in the job market are having trouble finding jobs then there will be some effect on decisions of college bound high school graduates seeking to prepare for vocational education careers

(c) alternative non-educational prospects for college prepared persons -- a function of the same pressures driving up demand for vocational courses (i.e., job availability in the private sector)

1.4.3 Resources

(i) Expenditures are computed in the model at three levels (as defined earlier): high school vocational and non-vocational per pupil costs; postsecondary vocational per pupil costs; 4 year college per pupil costs. The costs are computed by historical data on average per pupil

costs, times students in those levels.

(ii) This will allow us to say, if the system expands, it will add X to the total allocation of dollars for vocational education, and X_1, X_2, and X_3 distributions of costs among the three levels (secondary, postsecondary vocational education and college levels) -- if resources are not available, the system won't expand.

1.2 Tentative Conclusions

Our tentative conclusions are summarized below (bearing in mind that these are subject to further refinement and testing of model assumptions):

(1) Simple linear extrapolation of vocational enrollment at the secondary level, to 1986, as a percentage of all secondary enrollment, produces a tapering off of the vocational enrollment growth observed in the 1970's -- due primarily to a decline in the total secondary school population. Based on simple extrapolation, vocational enrollment, in absolute numbers, would be no greater than enrollment in 1978 (even if the percentage enrolled continues to rise at its historic rate). Therefore, the demand, generally, for high school vocational teachers is not expected to rise.

(2) At the postsecondary level, a gradual decline in rate of growth is expected, due primarily to demography, although no net decrease in enrollment in two year colleges is forecast to 1986. Instructor demand, generally, will rise gradually at the postsecondary level, but within fields now undersupplied, shortages will likely continue.

(3) Within vocational areas, the observed shortages and surpluses of instructors (trade and home economics, for example) are expected to continue. The time and funding limitations of this contract, however, do not allow for a modeling effort complex enough to simulate disaggregated differences in enrollment and

staff by fields within vocational and nonvocational education at either the secondary or postsecondary levels.

(4) The VTSD model (a system dynamics model of vocational supply and demand) produces output consistent with historical data, and projects a gradual decline in in vocational enrollments at the secondary level and postsecondary level to the year 2000. Three primary factors account for model output: a flattening of employment growth rates, decline of 14-21 year old population, and competition for educational resources. The reinstitution of selective service, as tentatively tested in the model, produces a stimulus at the post-secondary level after 1985.

2.0 TRENDS IN VOCATIONAL EDUCATION

2.1 Introduction

This section presents documented historical and projected trend data on vocational education enrollments and staff, together with factors assumed to be influencing changes in the vocational trends. The most important of these factors is demography. In the VTSD model, discussed in the next section, the fundamental assumption is that enrollments determine the justification for revenues, and revenues determine expenditures. Enrollment changes are a function of population growth, or decline, within given age cohorts, and the fraction of that population entering and remaining in vocational programs at the secondary and postsecondary levels. Demography is an exogenous variable, determined by birth rate and proportion of the total age cohort entering and remaining in the schooling system. Within the system, the following factors are assumed to affect enrollments, or act as constraints: availability of staff, or capacity, and the tradeoff of funds required for vocational education relative to general and academic education. Externally driven factors, which also determine enrollments, include rates of growth of vocationally defined employment, the relationship between total vocational employment in the labor force and enrollments in vocational education, and the rates of growth in professional employment (assumed to require academic or non-vocational preparation).

These factors, and the trend data, are discussed in subsequent subsections below as descriptive data. The data are later used to parameterize the VTSD model.

2.2 Vocational Education Trends

2.2.1 Demography. The well known trends in school-age population growth and decline are presented and discussed briefly. The unavoidable conclusion, simply put, is that fewer people will be in school at the secondary and postsecondary levels in this decade and the next as compared to the previous two decades. At the postsecondary level, enrollments are more influenced by factors of employment prospects but the

National Center for Educational Statistics and the Bureau of the Census consistently forecast a leveling off of postsecondary enrollments, although no absolute decline. Table 1 shows the 14 - 17 year old and 18, 19, 20 and 21 year old populations from 1967 to 1986 as projected by NCES and the Bureau of the Census.

Table 1

Population 14 - 17 Years Old, and 18, 19, 20 and 21 Years Old, 1967 - 1986 (thousands)

	14-17	18	19	20	21
1967	14,829	3,535	3,538	3,797	3,053
1970	15,341	3,796	4,062	3,669	3,578
1975	16,913	4,236	4,159	4,149	4,005
1980	15,618	4,188	4,303	4,342	4,258
1985	14,358	3,577	3,706	3,954	4,061
1986	14,202	3,526	3,610	3,765	3,881

Source: NCES, Projection of Educational Statistics to 1986-87, Tables B-1 and B-2.

2.2.2 Enrollments and Staff: All Programs. For the purposes of this study, the NCES data on historical and projected enrollments are used. (All school enrollment, expenditures and staff data include only public schools for purposes of comparison with vocational data.) The enrollment data, of course, are consistent with demographic data. Table 2 below shows enrollments in Grades 9 - 12, and enrollments in 2 year and 4 year colleges from 1965 to 1986. Enrollments at the secondary level and in 4 year colleges decline while 2 year college enrollments level off but continue growing through 1986.

Table 3 shows the number of instructional staff at the secondary and postsecondary level projected to 1986. As expected, the staff trend data are consistent with demographic and enrollment data: fewer instructional staff at the secondary and postsecondary level as this decade ends.

Table 2

Public School Enrollments in Grades 9 - 12 and Enrollments in 2 and 4 Year Colleges, 1965 to 1986 (thousands)

	9 - 12[1]	2 Year College[2]	4 Year College[3]
1965	11,610	1,173	4,748
1970	13,332	2,223	6,358
1975	14,304	3,970	7,215
1980	13,203	4,976	7,400
1985	11,963	5,839	7,042
1986	11,812	5,979	6,924

[1] Public schools only.

[2] Total enrollments, public and private institutions, part-time and full-time students.

[3] Total enrollments, public and private institutions, part-time and full-time.

Source: NCES, Projection of Educational Statistics to 1986-87, Tables 4, 6, and 7.

Table 3

Instructional Staff at the Secondary and Postsecondary Level, 1965 to 1986 (thousands)

	Secondary[1]	Postsecondary[2]
1965	746	317
1970	927	451
1975	1,016	594
1980	944	622
1985	884	607
1986	875	599

[1] Public classroom teachers.

[2] Full-time equivalent faculty, all institutions of higher education.

Source: NCES, Projection of Educational Statistics to 1986-87, Tables 17 and 23
NCES, Projection of Educational Statistics to 1983-84, Table 33

2.3 Vocational Educational Education

The available data on vocational education suggests three things: (a) enrollments in the 1970's are growing relative to enrollments in general education; (b) a large fraction of vocational education enrollments are in non-occupational programs; and (c) little shifting occurs among the percentages of students enrolled in various vocational areas.

2.3.1 Enrollments: All Vocational Programs. The available enrollment data consists mostly of total head counts. The exact full-time equivalent enrollments in vocational programs is not documented, but is estimated here from available data on FTE vocational staff, assuming student/staff ratios in vocational education are identical to all education programs. Table 4 below shows total enrollments in vocational education from 1971 to 1977.

Table 4

Enrollments in Vocational Education (millions)

	Secondary	Postsecondary	Adult
1971	6.5	1.1	2.9
1972	7.1	1.2	3.1
1973	7.3	1.3	3.4
1974	8.4	1.6	3.5
1975	9.4	1.9	4.0
1976	8.9	2.2	4.0
1977	9.6	2.4	4.2

Source: The Status of Vocational Education, School Year 1976-77, Tables 41 and 42
The Status of Vocational Education, School Year 1975-76, Figure 2.1 and Tables 43 and 45

Tables 5 and 6 below show total enrollments, 1972-1978, converted to full-time equivalent enrollments at the secondary and postsecondary levels. (No equivalent basis could be found for computing full-time adults enrolled in vocational programs.) The data show steady growth in enrollments partly due to demographic growth and partly due to increasing proportions

Table 5

Estimated Secondary Vocational Education Enrollments Based on Full-time Equivalent Teachers and Secondary School Student-Teacher Ratio

	Voc. Ed. Teachers[1]	Student/Teacher[2]	Estimated Enrollments
1972	110,796	19.1	2,116,203
1973	112,664	19.3	2,174,415
1974	127,201	18.7	2,378,658
1975	138,840	18.8	2,610,192
1976	138,322	18.5	2,558,957
1977	146,052	18.4	2,687,356
1978	154,728	18.3	2,831,522

[1] NCES, A Statistical Overview of Vocational Education, September 17, 1980, Table 14

[2] NCES, Projection of Educational Statistics 1986-87, Table 18

Table 6

Estimated Postsecondary Vocational Education Enrollments Based on Full-time Equivalent Faculty and Postsecondary Student-Faculty Ratio

	Voc. Ed. Faculty[1]	Student/Faculty[2]	Estimated Enrollments
1972	39,241	15.9	623,931
1973	40,626	15.5	629,703
1974	46,534	15.1	702,663
1975	50,437	14.8	746,467
1976	53,602	14.2	761,148
1977	59,626	14.2	846,689
1978	56,058	14.4	807,235

[1] NCES, A Statistical Overview of Vocational Education, September 17, 1980, Table 14

[2] Computed from Tables 8 and 23, Projection of Educational Statistics to 1986-1987, NCES

of the school population entering and remaining in vocational education programs. Table 7 and 8 show the FTE vocational enrollments at the secondary and postsecondary levels as a percentage of all enrollments at those levels. Secondary vocational enrollments rise from 11.5% of all students in 1972 to 15.5% of all students in 1978. Computed as simple annual percentage growth, vocational enrollments, relative to all enrollments, are rising at about 6/10ths of a percent each year at the high school level. By 1986 that would mean that vocational enrollments would be about 20% of total high school enrollment.

Given the projected level of secondary enrollment (grades 7 - 12) in 1986, a simple linear extrapolation of the data (using full-time equivalents) would predict about 3.0 million students in high school vocational education programs, or a net increase of about 231,000 students since 1978.

If one were to simply extrapolate enrollment growth in vocational education, based on annual enrollment growth rates in the 1970's, vocational enrollments would rise from 2.8 million students in 1978 to about 4.2 million in 1986. That would mean that vocational students would comprise 27% of the total high school enrollments, on a full-time equivalent basis.

The probability of one out of three high school students being enrolled full-time in vocational education would require a sizable reallocation of resources at the secondary level. That would mean a substantial decrease in resources available for academic programs and other general and special education programs not associated with vocational education. In short, the reality of such a reallocation occurring in this decade would create a "contest" for shrinking available resources at a time when such contests take on very significant meaning for professional jobs and would raise serious educational and political issues.

We will return to these points in the last section of the report.

2.3.2 Programs Within Vocational Education. The data by categories of enrollments, all levels and adult education, suggest that health and technical training are growing at the most rapid rate within vocational education, although consumer and home economics continues to enroll

Table 7

Estimated Secondary Vocational Education Enrollments as a Percentage of All Public Secondary Enrollments

	Voc. Ed. Enrollments[1]	Secondary Enroll.[2]	Percent
1972	2,116	18,421	11.5
1973	2,174	18,995	11.4
1974	2,379	18,671	12.7
1975	2,610	19,151	13.6
1976	2,559	18,905	13.5
1977	2,687	18,664	14.4
1978	2,832	18,265	15.5

[1]Estimated as follows: FTE Teachers X Student/Teacher Ratio

FTE Teachers from NCES, A Statistical Overview of Vocational Education, September 17, 1980, Table 14

Student/Teacher Ratio from NCES, Projection of Educational Statistics to 1986-87, Table 14

[2]NCES, Projection of Educational Statistics, 1986-87, Table 4 (Col. 7) (1977 and 1978 Intermediate-Alternative Projections)

Table 8

Estimated Postsecondary Vocational Enrollment as a Percentage of All FTE Higher Education Enrollments

(Enrollments in Thousands)

	Voc. Ed. Enroll.[1]	All Higher Ed. Enroll.[2]	Percent
1972	624	7,255	8.6
1973	630	7,454	8.5
1974	703	7,806	8.0
1975	746	8,481	8.8
1976	761	8,313	9.2
1977	847	8,604	9.8
1978	807	8,741	9.2

[1]Estimated as follows: (FTE Faculty) (Faculty/Student Ratio)

FTE Faculty from NCES, A Statistical Overview of Vocational Education, September 17, 1980, Table 14

Faculty/Student Ratio from NCES, Projection of Educational Statistics to 1986-87, Tables 8 and 23

about one-quarter of the total. Tables 9 and 10 below show a break-down of enrollment changes from 1971 to 1976 within eight major areas. The historical data on total enrollments by occupational area are shown in Table 11. Table 12 shows enrollment by occupatoinal area and level of schooling (secondary and postsecondary).

2.3.3 Vocational Staff. Tables 5 and 6 above show vocational staff (FTE) at the secondary and postsedonary levels. Table 13 below shows vocational staff for all vocational programs (secondary, postsecondary and adult) including full and part-time teachers, 1974 - 1978. Consistent with all previous data, staff in vocational education is increasing (although full and part-time distinctions aren't made in Table 13). Additional data in Table 14 shows full-time equivalent staff at the secondary, postsecondary and adult levels, again increasing from 1972 to 1978 at all three levels.

Table 15 shows the full-time equivalent staff in vocational education at the secondary and postsecondary levels as a percentage of all teachers. The secondary percentage rises from 11.5% to 15.5%; the postsecondary percentage rises from 8.6% to 9.2%.

Table 9

Percentage of Total Vocational Enrollment

By Occupational Area, 1971 - 1976

	Percentage		
	1970-71	1974-75	1975-76
Agriculture	8.0	6.9	6.9
Dist. Ed.	6.3	6.0	5.9
Health	2.9	4.2	4.5
Consumer and Home Ec.	26.8	23.0	23.0
Occupational Home Ec.	2.1	3.2	3.1
Office Occupations	24.2	20.2	20.3
Technical Education	3.4	3.1	3.2
Trade and Industry	22.5	20.6	20.3
Other	2.9	12.8	13.0

Source: Status of Vocational Education, School Year 1975-76, Ohio State University, National Center for Research in Vocational Education, Table 2.5

Table 10

Enrollment Growth by Occupational Area, Total Vocational Education, 1975 - 1976 (Enrollments in Thousands)

	Enrollments 1975 - 1976	Increase 1974-75	Percentage
Agriculture	1,060	47	4.7
Dist. Ed.	901	26	3.0
Health	685	68	11.1
Consumer and Home Ec.	3,515	152	4.5
Occupational Home Ec.	472	9	2.0
Office Occupations	3,114	164	5.6
Technical Education	485	38	8.4
Trade & Industry	3,120	115	3.8

Source: Status of Vocational Education, School Year 1975-76, Ohio State University, National Center for Research in Vocational Education, Table 2.6

Table 11

Enrollment in Federally Aided Vocational Education Classes by Type of Program (thousands)

	Total	Agric.	Dist. Ed.	Home Ec.	Trades Indus.	Health Occ.	Tech Ed.	Office Occ.	Other
1960	3,768	796	304	1,588	938	40	101	-	-
1964	4,566	861	334	2,022	1,069	59	221	-	-
1968	7,534	907	420	1,898	1,269	84	254	1,238	-
1972	11,711	896	640	3,466	2,398	337	337	2,352	1,305
1976	15,346	1,060	900	3,986	3,110	685	485	3,115	2,005
1978	17,599	1,006	962	4,119	3,403	759	528	3,312	3,509

Source: NCES, Digest of Educational Statistics, 1980, Table 150

Table 12

Enrollment in Federally Aided Vocational Education Classes by Level and Type of Program, 1968 - 1978 (thousands)

	1968	1970	1972	1974	1976	1978
Agriculture						
Sec.	528	551	603	659	712	715
Postsec.	11	23	35	47	68	58
Distributive						
Sec.	176	230	263	353	361	397
Postsec.	45	82	103	133	192	248
Health						
Sec.	21	32	59	104	108	132
Postsec.	65	102	177	228	290	233
Home Ec.						
Sec.	1,558	1,934	2,631	2,877	2,944	3,049
Postsec.	4	44	69	71	109	127
Office						
Sec.	1,060	1,331	1,508	1,766	1,824	1,935
Postsec.	225	331	360	426	620	670
Technical						
Sec.	36	34	39	40	35	39
Postsec.	105	152	189	231	310	330
Trades/Indus.						
Sec.	422	692	952	1,218	1,353	1,470
Postsec.	138	261	357	413	565	424
Other						
Sec.	42	310	1,223	1,610	1,643	3,224
Postsec.	-	17	46	46	76	51

Source: NCES, Digest of Educational Statistics, 1980, Table 151.

Table 13

Teachers of Federally Aided Vocational Education

Classes by Type of Program, 1974 - 1978

	1974		1975		1976		1977		1978	
	Total	%	Total	%	Total	%	Total	%	Total	%
Agriculture	14,943	(5.6)	15,528	(5.3)	16,774	(5.4)	17,255	(5.1)	17,668	(5.0)
Distributive	16,505	(6.2)	18,239	(6.2)	20,093	(6.5)	21,052	(6.3)	22,086	(6.2)
Health	19,505	(6.2)	21,517	(7.2)	24,189	(7.8)	26,807	(8.0)	28,569	(8.1)
Home Ec.	47,326	(17.8)	50,618	(17.2)	50,447	(16.3)	53,897	(16.1)	53,804	(15.2)
Office	58,153	(21.8)	66,849	(22.7)	67,132	(21.7)	70,891	(21.1)	69,980	(19.8)
Technical	14,936	(5.6)	16,243	(5.5)	17,047	(5.5)	18,606	(5.5)	21,498	(6.1)
Trades	74,314	(27.9)	80,097	(27.2)	83,490	(26.9)	91,277	(27.2)	87,856	(24.8)
Other	20,538	(7.7)	24,862	(8.5)	30,759	(9.9)	35,516	(10.6)	52,714	(14.9)
Total	266,220		294,053		309,931		335,301		354,175	

Source: NCES, Digest of Educational STatistics, 1980, Table 152

Table 14

Teachers of Vocational Education, Full-time Equivalents

	Secondary	Postsecondary	Adult	Total
1972	110,796	39,241	25,845	175,882
1973	112,664	40,626	28,404	181,694
1974	127,201	46,534	30,054	203,789
1975	138,840	50,437	32,881	222,158
1976	138,322	53,602	33,545	225,469
1977	146,052	59,626	37,959	243,637
1978	154,728	56,058	53,943	264,729

Source: NCES, A Statistical Overview of Vocational Education, September 17, 1980, Table 14

Table 15

Estimated Vocational Education Teachers At Secondary and Postsecondary Level as a Percentage of All Teachers

	Secondary[1] Voc.Ed. Teachers	All[2] Secondary Teachers	Percent	Postsecondary[3] Voc. Ed. Faculty	All[4] Faculty	Percent
1972	110,796	963,000	11.5	39,241	455,000	8.6
1973	112,664	986,000	11.4	40,626	481,000	8.4
1974	127,201	998,000	12.7	47,534	516,000	9.0
1975	138,840	1,016,000	13.7	50,437	574,000	8.8
1976	138,322	1,023,000	13.5	54,602	584,000	9.2
1977	146,052	1,014,000	14.4	59,626	604,000	9.9
1978	154,728	998,000	15.5	56,058	608,000	9.2

[1] NCES, A Statistical Overview of Vocational Education, September 17, 1980, Table 14.

[2] NCES, Projection of Educational Statistics to 1986-87, Table 17 (Col. 7) (1977 and 1978 Intermed. Alt. Proj.)

[3] See Note 1.

[4] NCES, Projection of Educational Statistics to 1986-87, Table 23.

2.3.4 Supply and Demand for Vocational Teachers. The primary document source of data on teacher preparation and demand for teachers is the NEA's annual report (Teacher Supply and Demand in the Public Schools). Table 16 below shows the NEA's estimate of vocational teacher supply and demand compared with supply and demand for all secondary teachers. In general, the vocational supply/demand pattern from 1968 to 1978 is similar to the general pattern: more new teachers than positions to be filled. There has been no serious shortage of vocational teachers on the whole, according to these data, although within certain fields, chronic shortages and surpluses exist. Table 17 shows secondary vocational teacher supply and demand by field from 1968 to 1978. Trade and industrial education have been consistently undersupplied with new teachers since 1968. Home economics and agriculture have been consistently oversupplied during this period. After the trade teacher supply and demand data are separated, the picture on the whole for much of the 1970's shows surpluses of vocational education teachers (Table 18).

Table 19 below shows vocational teacher supply (i.e., new graduates) as a percentage of total secondary teacher supply. The percentage ranges from about 15% to about 21%. Despite the increased enrollments in vocational education, relative to total enrollments, the supply of vocational teachers has not changed much since rising in the early 1970's and then falling.

For the purposes of model building (discussed in more detail later), it is assumed that (a) vocational teacher supply is affected by the general market condition for all teachers; (b) response to market conditions within various fields for teachers will reflect some sensitivity to changes, e.g., the rising demand for health educators will eventually produce more health educators, but there will be a delay between the market "signal" and changes in available supplies; and (c) constraints imposed by the system of teacher preparation will restrict supplies even when the market demand is high. It takes time for academic programs to train new instructors, develop new programs, to train instructors, or transfer or release instructors not needed, or dismantle or reduce undersubscribed programs. In short, the same system that produces high school vocational teachers

Table 16

Secondary Vocational Teachers:

Supply and Demand All Fields, 1968 - 1978

	Demand for[1] Voc.Ed.Teachers	Supply of Voc.Ed. Teachers	Supply of All Secondary Teachers	Demand for All Secondary Teachers
1968	11,112	22,775	136,242	72,835
1969	12,061	25,287	160,756	78,213
1970	13,985	26,709	167,802	95,468
1971	17,702	29,041	176,237	106,000
1972	19,673	38,707	182,715	108,000
1973	14,589	26,189	165,639	73,628
1974	10,889	25,894	167,839	50,800
1975	10,540	21,685	144,931	- -
1976	10,950	18,730	121,580	48,350
1978	8,650	15,535	102,079	41,300

[1] Includes Agriculture, Business Education, Distributive Education, Home Economics, Industrial Arts and Trade. (Distributive Education not included in 1968, 1969, 1970 and 1973 figures.)

Source: NEA, Teacher Supply and Demand in Public Schools, 1968-1978

Note: Supply includes new graduates, both bachelors degrees and first professional degrees, certified to teach. Demand is the estimated teaching vacancies that could be filled by beginning teachers, newly certified to teach, calculated as turnover rate of encumbent teachers in each secondary field.

Table 17

Secondary Vocational Teachers: Supply and Demand by Field of Study, 1968 - 1978

Year	Agriculture		Bus. Education		Dist.Education		Home Ec.		I. A.		Trade	
	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
1968	2047	711	9001	4123	-	-	6780	2807	4338	2248	609	1223
1969	1554	488	10258	4267	-	-	7594	2990	5205	2994	676	1322
1970	1921	625	10827	4799	-	-	8038	3717	5190	3638	733	1206
1971	1761	1060	11195	5936	868	530	8615	4346	5692	3816	910	2014
1972	1761	1060	10651	5875	951	653	8728	5005	5692	3816	924	3264
1973	1821	1306	9410	4082	1102	-	8141	3882	5769	3892	1048	1427
1974	1675	882	8753	2692	854	356	7628	2692	5847	2235	1137	2032
1975	1461	632	7307	2530	718	316	6367	2530	4880	2635	952	1897
1976	1241	1050	6318	2450	677	400	5529	2350	4175	2400	790	2300
1978	1031	700	5247	2100	562	300	4592	1800	3467	1550	636	2200

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Source: NEA, Teacher Supply and Demand in Public Schools, 1968-1978

Note: Supply includes new graduates, both bachelors degrees and first professional degrees, certified to teach (NEA, 1968-1978). Demand is the estimated teacher vacancies that could be filled by beginning teachers newly certified to teach, calculated from turnover rate of encumbant teachers in each secondary field.

Table 18

Supply and Demand: Trade Teachers and Other Vocational Teachers

	Trade		Other[1]	
	Supply	Demand	Supply	Demand
1968	609	1223	22,166	9,889
1969	676	1322	24,611	10,739
1970	733	1206	25,976	12,779
1971	910	2014	28,131	15,688
1972	924	3264	37,783	16,409
1973	1048	1427	25,141	13,162
1974	1137	2032	24,757	8,857
1975	952	1897	20,733	8,643
1976	790	2300	17,940	8,650
1978	676	2200	14,899	6,450

[1] Other includes Agriculture, Business Education, Distributive Education, Home Economics, and Industrial Arts. (Distributive Education not included in 1968, 1969, 1970 and 1973 figures.)

Source: NEA, Teacher Supply and Demand in Public Schools, 1968-1978

Table 19

Vocational Teacher Supply as a Percentage of Total Teacher Supply

	Vocational	All Teachers	Percent
1968	22,775	136,242	16.7
1969	25,287	160,756	15.7
1970	26,709	167,802	15.9
1971	29,041	176,237	16.4
1972	38,207	182,715	21.2
1973	26,189	165,639	15.8
1974	25,894	167,839	15.4
1975	21,685	144,931	14.9
1976	18,730	121,580	15.4
1978	15,535	102,079	15.2

Source: NEA, Teacher Supply and Demand in Public Schools, 1968-1978

must also produce the faculty to teach teachers and it must also supply postsecondary teachers and the faculty to prepare postsecondary teachers. Long time delays and periods of over- and under-supply should surprise no one. It should also be noted that no precise data could be found to establish base-line trends on the level of preparation or source of vocational instructors at the secondary or postsecondary level. Clearly, not all instructors are graduates of schools of education or hold college credentials. However, that would likely be the case for home economics, office and agriculture instructors. The remaining staff would represent some mix of college and on-the-job preparation, although exactly what that mix is remains indeterminate. For the purposes of this study and the VTSD model, we assume that all secondary and postsecondary teachers are products of schools of education.

2.4 Costs of Vocational Education

This section examines data on vocational education costs and compares those costs to general education. Table 20 below shows total vocational expenditures for 1974 and 1976 to be a relatively constant percentage of all education expenditures (public) staying at about 4%.

Table 20

All Vocational Expenditures Compared to All Public Education Expenditures, 1974 and 1976 (billions)

	Vocational	General	Percent
1974	$ 3.1	$ 80.1	3.8%
1976	$ 3.9	$ 100.0	3.9%

Source: The Status of Vocational Education, School Year 1976-77, National Center for Research on Vocational Education, Ohio State, Table 63.

Table 21 shows secondary vocational expenditures compared to general secondary expenditures (public). There has been a gradual increase in percentages of total education funds allocated to vocational education at the secondary level -- rising from 8.3% in 1971-72 to 9.5% in 1976-77.

Table 21

Vocational Education Expenditures at Secondary (9-12) Level Compared to All Expenditures (Public)

	Vocational Secondary*	Public Secondary	Percent
1971-72	1,645,224	19,840,000[1]	8.3
1973-74	2,167,727	-	
1974-75	2,589,655	-	
1975-76	2,922,905	28,331,738[2]	10.3
1976-77	2,961,934	31,283,650[3]	9.5

*Source: The Status of Vocational Education, School Year 1976-77, National Center for Research on Vocational Education, Ohio State, Table 63.

[1] NCES. Digest of Educational Statistics, 1974, Table 26

[2] NCES. Digest of Educational Statistics, 1977-78, Table 19

[3] NCES. Digest of Educational Statistics, 1979, Table 19

Table 22

Per Pupil Expenditures for Vocational Education at the Secondary Level Compared to General Education Expenditures

	Vocational[1] Per Pupil Expenditures	General[2] Education Per Pupil Expenditures	Percent
1971	778	990	78.5
1974	912	1,207	75.6
1976	1,142	1,504	75.9

[1] The Status of Vocational Education, School Year 1976-77, National Center for Research in Vocational Education, Ohio State, Table 63. Note: Per pupil expenditures computed by using FTE enrollments at secondary level -- see Table 5.

[2] NCES, Digest of Educational Statistics, 1980, Table 21

Table 22 shows the estimated per pupil expenditures of general education at the elementary-secondary level, compared to vocational per pupil expenditures at the secondary level. This is a somewhat crude estimate because precise documented data on high school per pupil expenditure is not readily available. Thus, both elementary-secondary levels are used. In addition, no precise documented estimate of full-time equivalent enrollments at the secondary level in vocational education is readily available; thus, the figures used to compute per pupil expenditures (see Table 5) are estimates based on faculty and pupil-teacher ratios for all education programs.

From the data in Table 22, it would appar that total per pupil costs are rising at about the same rate as vocational per pupil costs, but are about 25% higher. Since total costs include general, special and vocational costs, it is not possible to make any precise comparison. It is not possible to compare costs between areas of vocational education (e.g., trade, agriculture, etc.) or between areas of vocational education and general education (e.g., math, science, English, etc.). It would be expected that per pupil costs (operational) would vary primarily because of class size differences, but no readily available data could be found to estimate such differences. Finally, because of higher capital and equipment costs, it would be expected generally that vocational per pupil costs would be higher than general education costs, but lower than special education (because of small class sizes in special education. However, precisely what these differences are remains to be discovered. For the purposes of model building, we assume that vocational per pupil costs are slightly higher than non-vocational per pupil costs.

3.0 VOCATIONAL TEACHER SUPPLY/DEMAND MODEL

3.1 Introduction

This section is divided into two parts: (1) Description of the VTSD Model; and (2) Model Output. The VTSD model is initially described in Section 1.0 of the report. As stated earlier, the purpose is not to produce exact point-in-time predictions. The purpose of the model is to gain a deeper understanding of the dynamic structures, and their assumptions, which produce whole model behavior. The VTSD model does produce data paralleling historical trends in vocational education, but more importantly, it allows the reader (and model builders) to understand explicitly the assumptions which produce the trend data (model output).

It should be noted that the scope of the contract does not allow for elaborate model testing. Thus, the conclusions are incomplete and tentative. In general, what one finds is logically consistent: A build-up of enrollments in the early 1970's, increases in teachers, followed by gradual decline in growth rates in the 1980's and 1990's. Bear in mind that demography alone would predict a tapering off of enrollment growth in the 1980's and 1990's, even if the percentage of students in vocational education continued rising in a linear fashion (see discussion in Section 2.3.1). In short, what the model leads one to tentatively conclude is a gradual end by the mid-1980's of the rush of rising numbers of students enrolling in vocational education which occurred in the 1960's and 1970's due in part to the following: (a) demography; (b) flattening of employment growth rates (rising at a slower rate); and (c) competition for shrinking resources at all levels of education. To the extent that these factors change in ways not anticipated, the VTSD model output is wrong.

Finally, the reader will note that the VTSD model does not disaggregate enrollments and staff into occupational training areas. Keeping track of separate areas of vocational education may prove to be important in policy analysis and forecasting, but is several orders more complex than the scope of the contract allows. And, for similar reasons of

complexity and time limitations, the model does not attempt to simulate supply/demand dynamics for adult vocational education.

3.2 VTSD Model Structure

3.2.1 People Flows. The model contains the following population sectors: (a) Primary School Population; (b) High School Population (divided into vocational and non-vocational); (c) Postsecondary Population in Vocational Education; (d) School of Education Population. Each sector of the model tracks students, first, moving them into high school vocational and non-vocational education, and from high school into college (three tracks: college general, schools of education, post-secondary vocation). The model does not contain an employment sector other than teaching. The teaching employment sector tracks teachers through a Teacher Job Applicant Pool and into teaching positions in vocational and non-vocational education at the secondary and post-secondary level.

3.2.2 High School Population. The Primary School Sector serves only as a generator of students for the High School Sector. Students leaving primary school (8th grade) enter either vocational or non-vocational tracks and stay in these tracks until graduation from high school four years later. (This is an obvious departure from reality and serves simply to keep track of full-time equivalent enrollments in vocational and non-vocational education.) The fraction entering vocational education is determined by the following factors: Effects of vocational employment (discussed below); effects of capacity; and effects of cost tradeoffs. The fraction entering the college bound pool is exogenously determined, while the fraction seeking to enter schools of education is internally generated as a function of teacher supply/demand dynamics.

The effect of capacity means that enrollments are constrained by available faculty, i.e., too few faculty will reduce the fraction entering vocational education, and conversely the existence of surplus faculty will have a positive effect on the fraction entering vocational education. The tradeoff factor is intended to represent constraints on enrollment due to competition for total available resources. When the

ratio of funds expended for vocational education begins to exceed an initial ratio, the fraction of entrants to vocational education is constrained. In model runs, this is not a significant factor until the late 1980's, when demography begins to seriously reduce the total pool of students. Then, competition for total funds disfavors vocational education.

3.2.3 Employment Effects. In this section, the parameters for employment effects are first presented in terms of historical and projected employment growth rates. A second sub-section discusses the relationship between employment growth and vocational enrollments. Employment effects in the VTSD model are analogous at both the secondary and postsecondary levels.

3.2.3.1 Estimated Parameters of Employment. Lecht (1977)* estimates (based on Bureau of Labor statistical data) that growth rates in employment in all occupations for the period 1960-1985 (see his Table C.5) will be slower at the end of the period than in the beginning:

Employment (millions)				Average Annual Growth Rate (%)			
1960	1970	1980	1985	1960-70	1970-80	1970-85	1980-85
65.7	78.6	95.8	101.5	1.8	2.0	1.7	1.2

Lecht's (1977) data, defining occupations for which vocational education is offered (see his Table C.12), show annual rates of increase for 1970-1980 to be approximately equal to the overall average, i.e., 2.1%.

The data on employment growth for fields requiring college preparation (see his Table C.5) show the following average annual rates of growth (see following page):

* Lecht, Leonard. Occupational Choices and Training Needs, Prospects for the 1980's. New York: Praeger, 1977.

	Employment (millions)				Average Annual Growth Rate (%)			
	1960	1970	1980	1985	1960-70	1970-80	1970-85	1980-85
Professional Technical Kindred	1.2	2.1	3.2	3.7	5.8	4.3	3.9	3.0
Managers, Admin.	6.2	5.8	7.8	7.9	-.7	3.1	2.1	.2
Total	7.4	7.9	11.0	11.6	5.1	3.7	3.0	1.6

The data on employment growth for fields traditionally requiring less than college preparation (see his Table C.5), show the following rates of growth:

	Employment (millions)				Average Annual Growth Rate (%)			
	1960	1970	1980	1985	1960-70	1970-80	1970-85	1980-85
Clerical Kindred	4.9	8.1	10.7	11.9	5.0	2.8	2.5	2.0
Craft Kindred	6.5	8.2	9.8	10.6	2.4	1.7	1.7	1.7
Operations	5.8	6.9	8.0	8.3	1.8	1.5	1.3	.7
Service	2.7	4.3	5.9	6.7	5.0	3.0	2.9	2.5
Sales	4.1	4.6	5.8	6.1	1.1	2.4	1.8	.8
Total	24.0	32.1	40.2	43.6	3.1	2.3	1.7	1.6

In short, the predicted growth rate in employment, both for occupations traditionally requiring college preparation (baccalaureate) and vocational education, are expected to decline slightly to the middle of the present decade.

3.2.3.2 Relationship Between Growth in Employment and Growth in Vocational Education Enrollments. For the purpose of establishing parameters for the VTSD model, regarding vocational education enrollments, the relationship between vocational enrollments and employment is analyzed (48 categories for the period 1970-77 and 1970-80, respectively). The data are taken from Lecht's (1977) Table C.12. The

estimated relationships are shown below in the form of regression coefficients. The variables are specified as follows:

Variable 1	Vocational education enrollments per 100 employed (in each occupational category), 1970
Variable 2	Average annual growth rate in enrollments (in each occupational category), 1970-77
Variable 3	Average annual growth rate in employment, 1970-80 (in each occupational category)

The average annual growth rates for enrollments and employment are:

Employment	2.762%
Enrollment	13.254%

Taking into consideration the initial level of enrollment (per 100 employed), the multiple correlation between enrollment and employment is .380; the adjusted R^2 is .106. The regression results are presented below.

STEP 1

Variable selected 3

Sum of squares reduced in this step 398.823
Proportion of variance of Y reduced 0.085
F for this variable (D.F.=1, 46) 4.253

Cumulative sum of squares reduced 398.823
Cumulative proportion reduced . . . . . 0.085 of 4712.039

Multiple correlation coefficient . . . . 0.291 (adjusted RSQ = 0.065)
F for analysis of Vari. (D.F.= 1,46) . . 4.253
Standard error of estimate 9.683

Variable	Reg. Coef.	Std. Error-Coeff.	Computed T	Beta Coef.
3	1.61551	0.78332	2.062	0.29293
Intercept	8.79125			

STEP 2

Variable selected 1

Sum of squares reduced in this step 281.548
Proportion of variance of Y reduced 0.060
F for this variable (D.F. = 1, 45) 3.143

STEP 2 (continued)

Cumulative sum of squares reduced 680.371
Cumulative proportion reduced . . . . . 0.144 of 4712.039

Multiple correlation coefficient . . . . 0.380 (adjusted RSQ = 0.106)
F for analysis of Vari. (D.F. = 2, 45) . 3.797
Standard error of estimate 9.465

Variable	Reg. Coeff.	Std. Error-Coeff.	Computed T	Beta Coef.
3	1.54064	0.76686	2.009	0.27744
1	-0.18385	0.10371	-1.773	-0.24481
Intercept	11.64089			

If all other things were equal, the expected impact of average annual employment rate increases on vocational education enrollment rates would be as follows: An increase in the average annual employment rate (within the 48 categories) of 1% (i.e., from 2.76% to 3.76%) would push vocational enrollment annual growth rate from 13.254% to 14.864%. However, the total variance in vocational enrollment explained by employment rate is relatively small, 10%, even taking into consideration that some fields are heavily over-enrolled or under-enrolled to begin with. For example, the following fields show enrollments of more than 25 students per 100 employees, 1970-77.

	Enrollments per 100 Employees	Annual Growth Enrollments	Annual Growth Employment
Computer processing	29	-0.4	3.7
Clerical/Scretarial	57	5.6	2.6
Aircraft Maint.	29	1.0	2.9
Drafting	35	5.5	3.0
Communications	41	9.2	1.6
Printing	30	10.2	1.8
Firemen	55	17.6	3.7
Woodworking	26	18.7	1.5

Growth in these fields reflects to some extent expected time delays -- rapid employment growth from 1960-1970, but a reduced rate of increase since that period.

3.2.3.3 Conclusions: Employment Effects. On the whole, the existing data, admittedly limited, suggest that during the initial phase

of vocational education growth (1970-1977), the primary causal factor was not employment growth within occupational categories. There is some relationship. The regression effects shown above suggest that about 10% of the variation in enrollment growth within occupations is due to employment growth rates. That, of course, leaves 90% of the variance to be explained. As in the case of all complex systems, one doesn't expect to be able to explain most of the variance. In this particular regression model, time delay may be very important. It takes time for enrollments by occupation to reflect changes in employment growth. On the whole, one would expect vocational enrollments over time to rise, and for some time following, an increase in demand due to employment growth in various occupations. Enrollments may continue to rise even when employment shows a decline in rate of growth -- creating the typical system dynamics pattern of oscillating cycles.

Perhaps the most important factor in time delay is "sunk costs". First, it takes time to acquire the needed human and physical resources to train students in a given occupation. Second, and very importantly, once monies are invested in these resources, it takes even more time to abandon them and shift to new resources. For example, once home economics and agricultural teachers are hired, facilities constructed and equipped, it takes time to shift to other occupations, e.g., computer programming. The presence of "capacity" will act to artifically produce demand, even when employment considerations are irrational. Furthermore, it seems clear from these data that students continue to enroll in vocational programs, not so much for vocational education leading to employment, but for avocational interests. The number of students in agriculture and home economics, for example, far exceeds any rational consideration of employment needs (except as future teachers of those subjects).

3.2.4 Postsecondary Vocational Population. The flow of students into postsecondary vocational education, in the VTSD model, comes from two sources: (a) Fraction of students graduating high school with vocational training who enter postsecondary vocation programs; and (b) fraction of non-vocational high school graduates not going to four-year colleges but entering postsecondary vocational programs. The fraction

of high school graduates entering postsecondary vocational education is determined by the effects of employment, effects of capacity, and effects of cost tradeoffs (all discussed above in sections 3.2.2 and 3.2.3).

3.2.5 School of Education Population. The flow of students into and out of schools of education in the VTSD model constitutes the only supply source of teachers for postsecondary and vocational education. The fraction of students entering schools of education to prepare for teaching careers is determined by the following: (a) fraction of the college-bound high school graduates seeking admission to schools of education (in turn, determined by teacher job prospects); (b) the fraction of SED applicants accepted by schools of education (in turn, determined by the number of students available as candidates), and (c) SED capacity. The crucial determinant of teaching prospects is the size of the teacher surplus (teachers hired relative to teachers available). The pool of available teachers consists of new graduates and those reentering the teacher market after an absence.

The supply of vocational teachers is a fraction of the new graduates of schools of education and those in the reentry pool. The fraction of new graduates in vocational education is determined by the demand for vocational teachers (in turn, determined by enrollments in vocational education).

3.2.6 Supply and Demand. The model assumes that the hire-fire rate for vocational teachers at the secondary level is a function of desired teachers (determined by student/teacher ratios) and available teachers to be hired (determined by those available from the teacher job applicant pool). Since the total fraction of students seeking admission to schools of education is a function of general teacher demand, the eventual supply of all categories of teaching is affected by general teacher demand. The model assumes that even if vocational teacher demand is rising, available supplies may be failing because overall teacher demand is falling.

The hiring rate is constrained by available teachers, i.e., even though school systems might want to hire more vocational teachers, the rate at which such teachers may be hired is affected by supplies. In

turn, the supply of teachers credentialed in vocational education is being affected by the rate of hiring.

3.3 Dynamics of the VTSD Model

The dynamic relationships in the VTSD model are depicted below in simplistic form as a series of causal look diagrams. (The more elaborate and complete form of the model is a series of simultaneous equations used in a computer simulation of the dynamic system.) The arrows connecting the variables in the causal loop diagrams represent causal feedback. A "+" sign means that the variables rise or fall in concert, in a ceterus paribus sense, e.g., as the fraction of students entering vocational education goes up, enrollments go up, all other things being equal. A "-" sign means the variables vary inversely. If A goes up, B goes down. For example, if expenditures for vocational education rise, relative to total education expenditures, eventually that will cause the fraction entering vocational education to fall (for reasons discussed earlier and labelled "political").

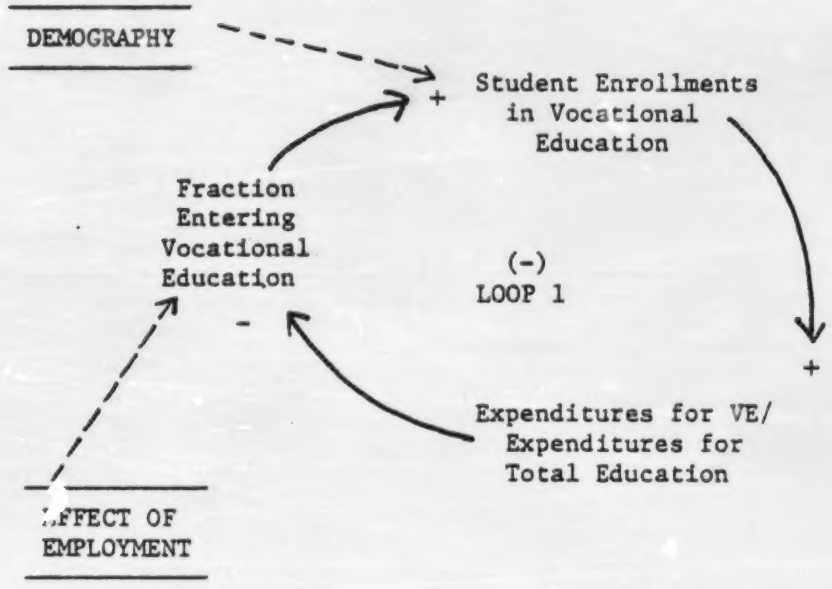
A. LOOP 1: Enrollments

This loop (Figure 1) depicts the basic feedback loops affecting flows of students into vocational education, and determines enrollment levels. In short, student enrollments are determined by the fraction entering (and exiting) and by demography. As discussed earlier, the fraction of students entering vocational education may rise (linearly) in the 1980's without causing enrollments to rise simply because total high school student population will decline.

Three additional factors affect the fraction of students entering vocational programs: Employment growth (discussed earlier); the expenditure ratio (also discussed earlier); and capacity, i.e., too many students relative to faculty resources will reduce the fraction entering, and too few students will increase the fraction entering.

Figure 1

Vocational Enrollments

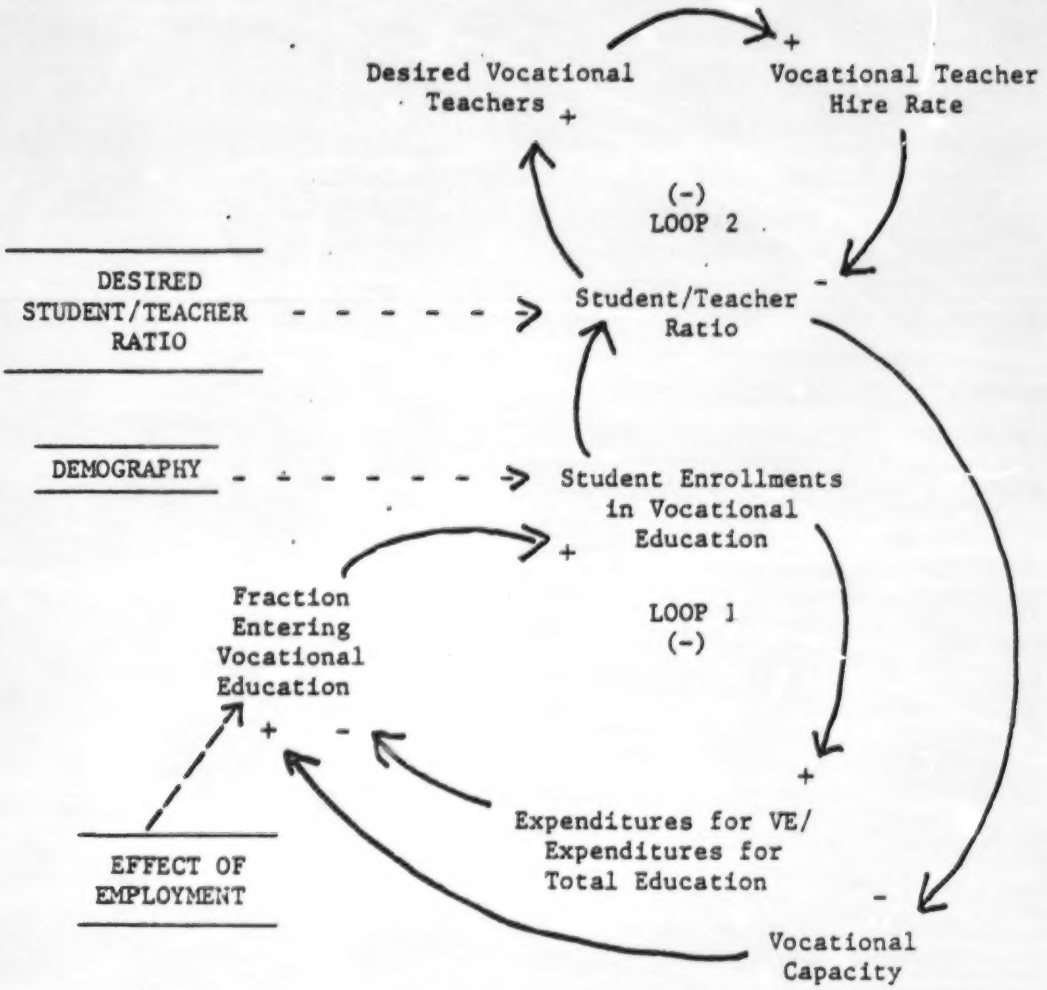


B. LOOP 2: Vocational Teacher Demand

This loop (Figure 2) depicts feedback in the vocational teacher demand sector. If the number of students rises, relative to the number of encumbent teachers, the desire to hire more teachers rises. If desire to hire more teachers rises, more will be hired (if available). If not available, then student/teacher ratio rises and again adds to the pressure on the system to hire. Conversely, if the number of students declines, relative to encumbent teachers, the desire to hire goes down. If normal teacher turnover rate does not balance student/teacher ratio at some desired level, teachers are fired. Reflecting normal "political" considerations, in the model, more time is required to fire than hire teachers.

Figure 2

Vocational Teacher Demand



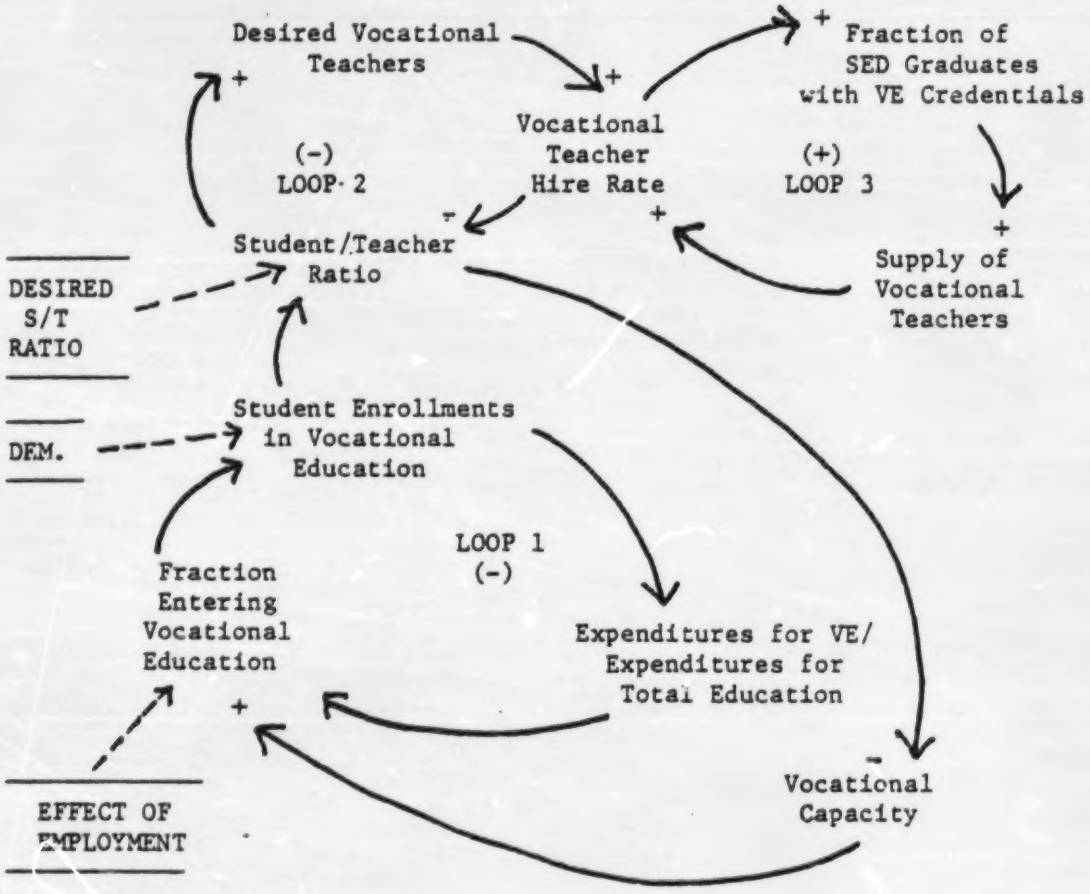
C. LOOP 3: Vocational Teacher Supply

This loop (Figure 3) depicts feedback affecting the flow of credentialled teachers to be hired. If teachers are being hired, the fraction graduating from teachers colleges with vocational credentials will increase -- after a 4 year time delay to allow for switching of majors and new starts in vocational education to occur and materialize as graduates. Note that there is a self-reinforcing feedback loop built into this

process: The hire rate determines changes in the fraction of supplies, and supplies determine the number who can be hired. (In reality, school systems caught without available credentialled teachers would likely resort to hiring, temporarily, some unqualified teachers.)

Figure 3

Vocational Teacher Supply



D. LOOP 4: Total Teacher Supply

This loop (Figure 4) depicts the system of teacher supplies in general. The system is driven by demography. If teacher demand rises,

the fraction of college bound seniors seeking to enter SED's goes up. Under the circumstance, SED's can afford to become more selective and still admit more students. Enrollments rise and graduates increase -- eventually meeting and then exceeding demand. The selectivity factor and time delays cause a cyclical pattern of oversupply, followed by down turns in the fraction of college bound seniors seeking entrance to SED's, still less selectivity, and only later fewer enrollments and graduates; the period of oversupply is followed by a period of undersupply. (Note that demography affects SED acceptances, and can create surpluses or shortages of enrollments independent of the fraction of acceptances.) Figure 4 will be found on the following page.

3.3 Model Output

3.3.1 Base Run. The Initial Base Run of the VTSD model shows a consistent pattern of rising demand for vocational teachers in the 1960's, followed by declining demand in the 1980's and 1990's. Due to constraints on the availability of vocational teachers in the 1960's and early 1970's, the actual hiring of qualified vocational teachers lags behind the desired hire rate up to about 1980, but not afterwards (Figure 5). The general pattern is one of teacher shortages in vocational education for most of the 1960's and early 1970's, followed by a gradual oversupply in the 1980's and 1990's (Figure 6). The primary causal factor is rising enrollment through 1980, followed by a gradual decline (Figure 7). During the period of rising enrollment, student/teacher ratio also increases as available qualified teachers fall below demand (Figure 7).

The pattern of SED applications and acceptance policies is consistent with earlier assumptions, i.e., as the demand for teachers rises in the 1960's and early 1970's, the fraction of college bound seniors seeking SED admission rises and then falls in the 1980's and begins rising in the 1990's (Figure 8). As the applicant pool increases, and as the pool declines, selectivity declines (Figure 9). The available supply of teachers rises and falls correspondingly.

3.3.2 Boosting Vocational Enrollment. The Base Run output produces a rate of vocational enrollment increase (and thus teacher

Figure 4

Total Teacher Supply

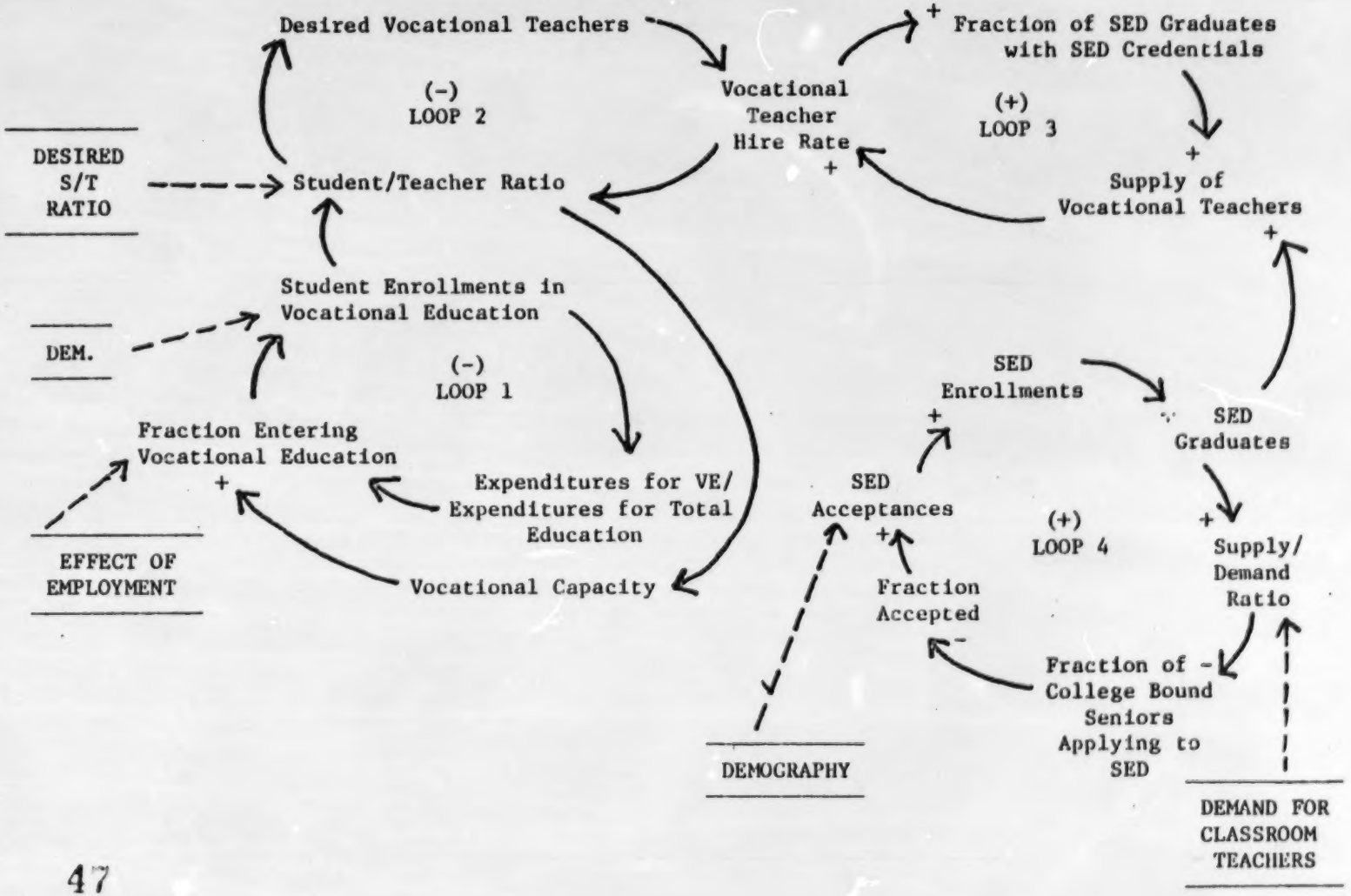
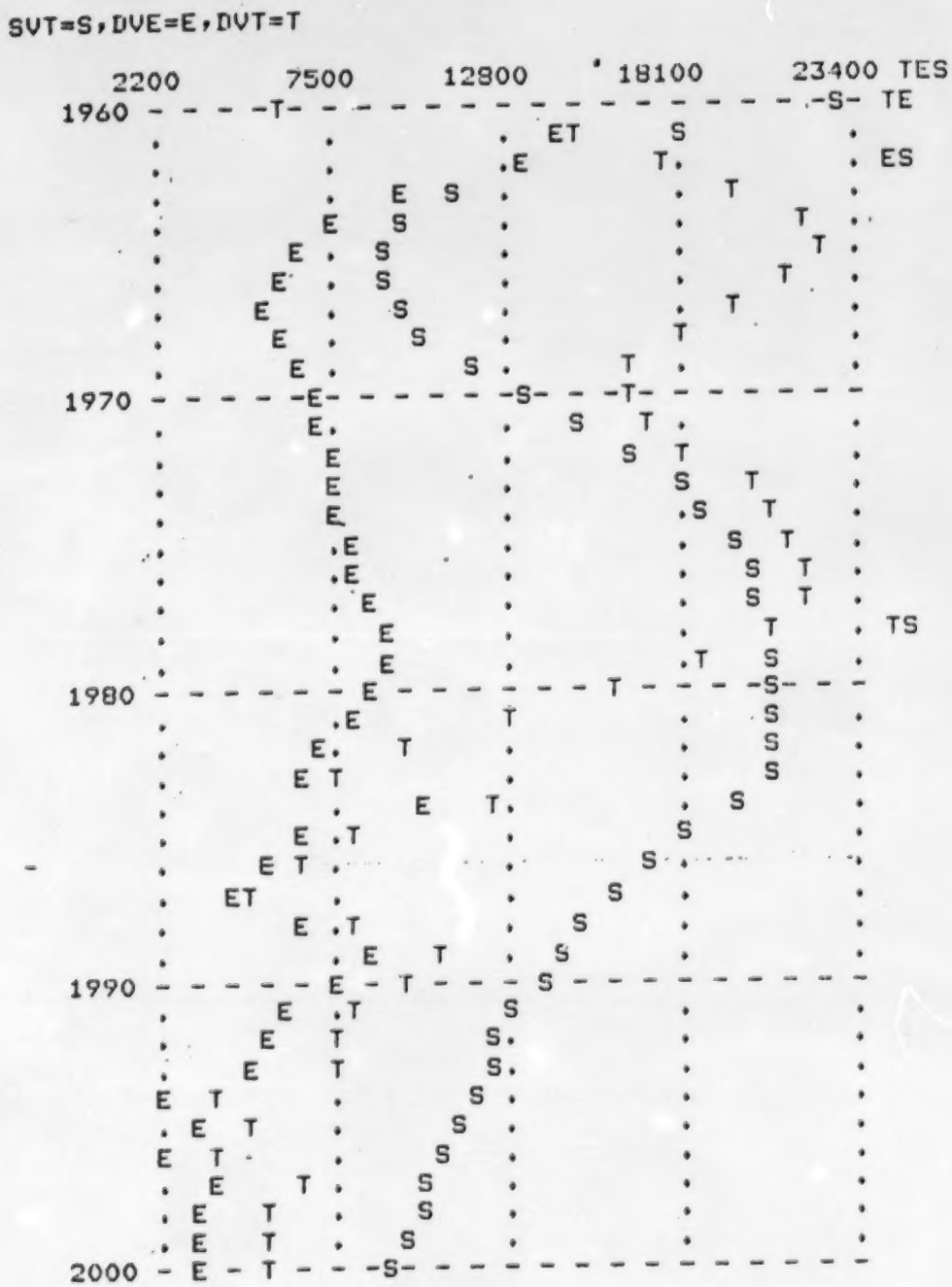
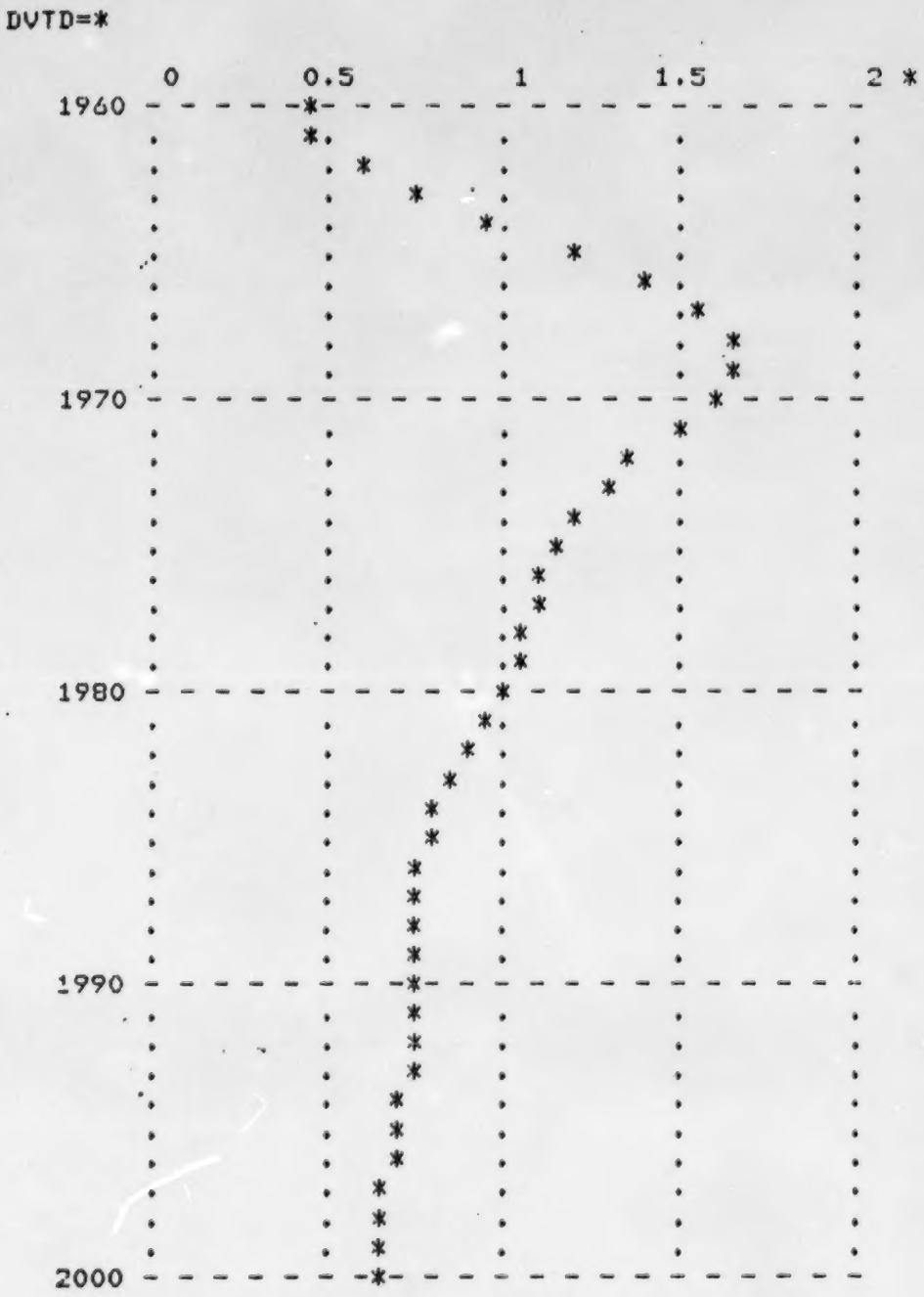


Figure 5



SVT Supply of Vocational Teachers
DVE Demand for Vocational Educators (Actual Hire Rate)
DVT Desired Vocational Teachers (Based on S/T Ratio)

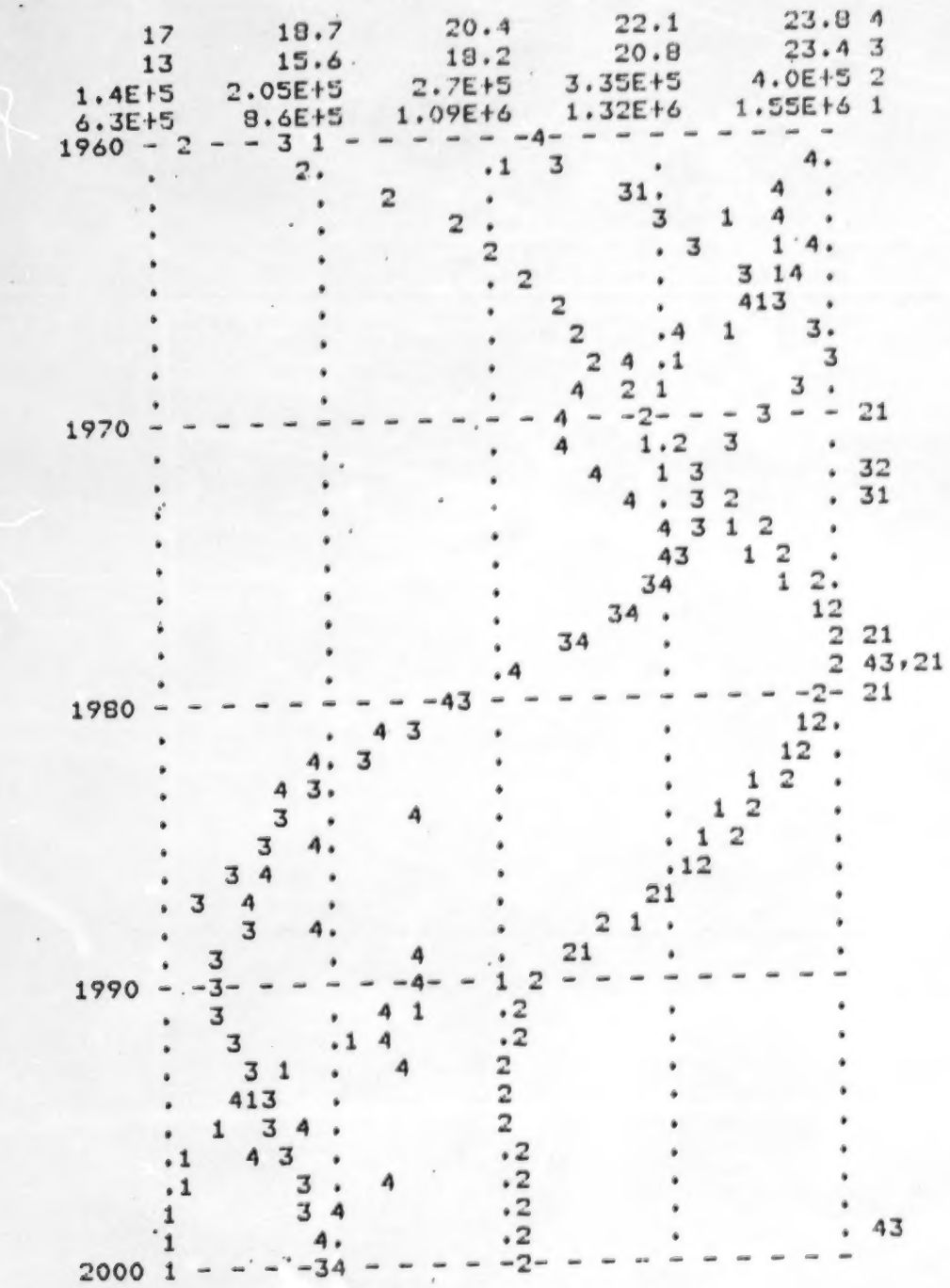
Figure 6



DVTD Index of Desired Vocational Teachers Relative to Supply (1.0 - Balance)

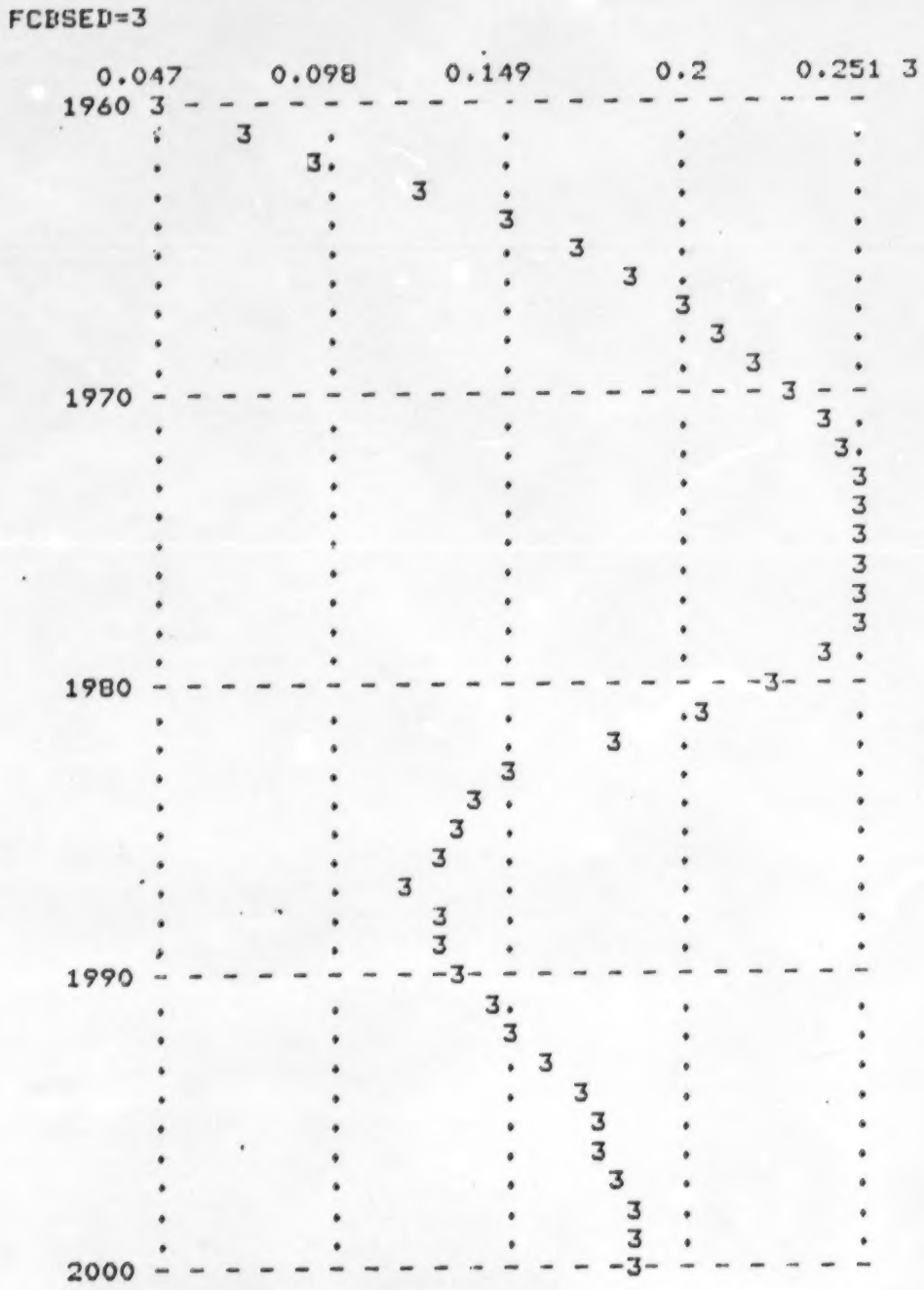
Note: Period 1960-1980 shows a higher desired hire rate than available supplies. The period 1980-2000 shows a lower desired hire rate than available supplies.

Figure 7



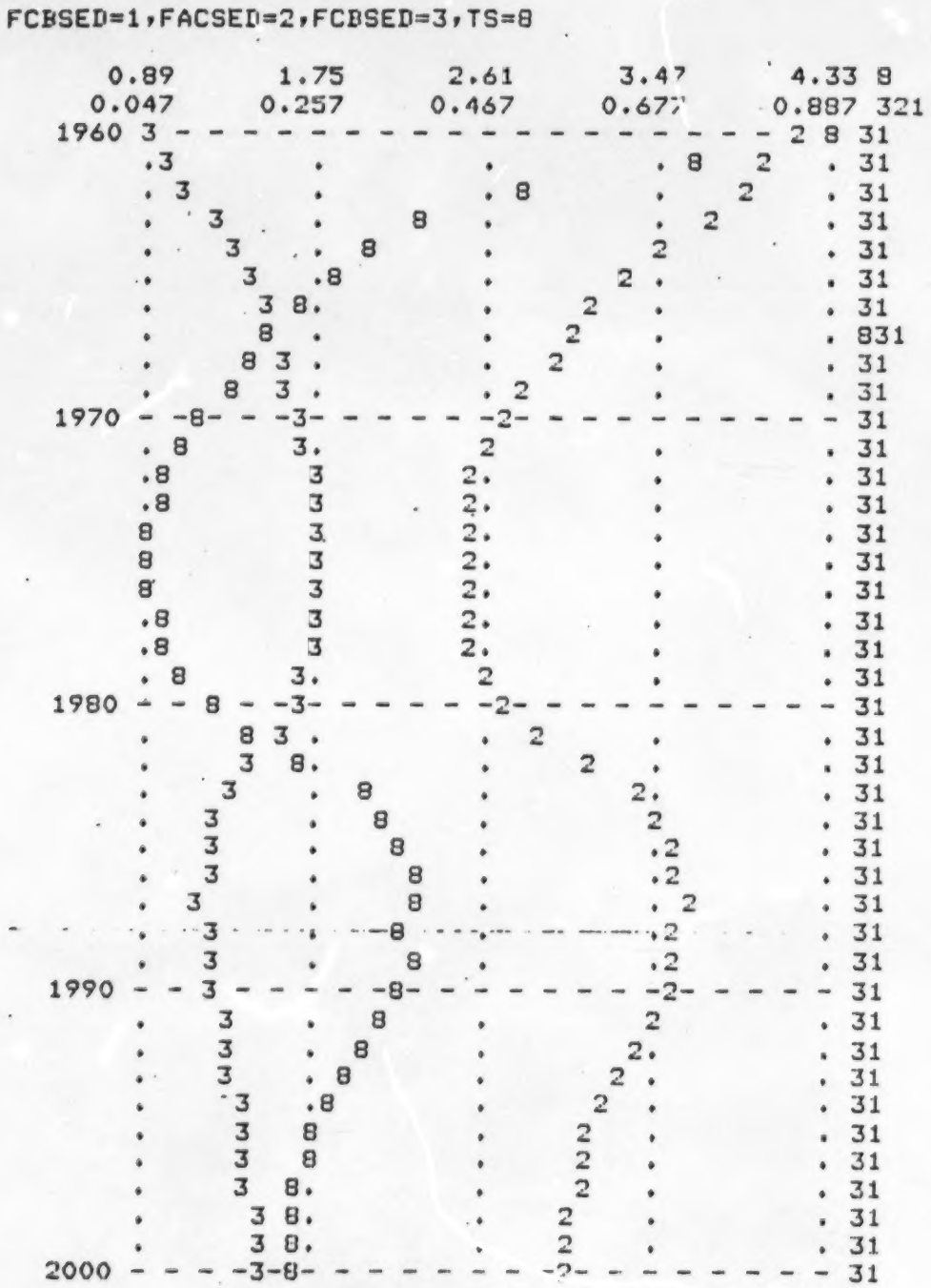
VHSP Vocational High School Population
PSVS Postsecondary Vocational Students
RPSVTS Ratio of Postsecondary Vocational Students to Teachers
RVSVF Ratio of High School Vocational Students to Teachers

Figure 8



FCBSED Fraction of College Bound High School Seniors Seeking Admission to Schools of Education

Figure 9



FCBSED Fraction of College Bound High School Seniors Seeking Admission to Schools of Education

FACSED Fraction of Applications Accepted by Schools of Education

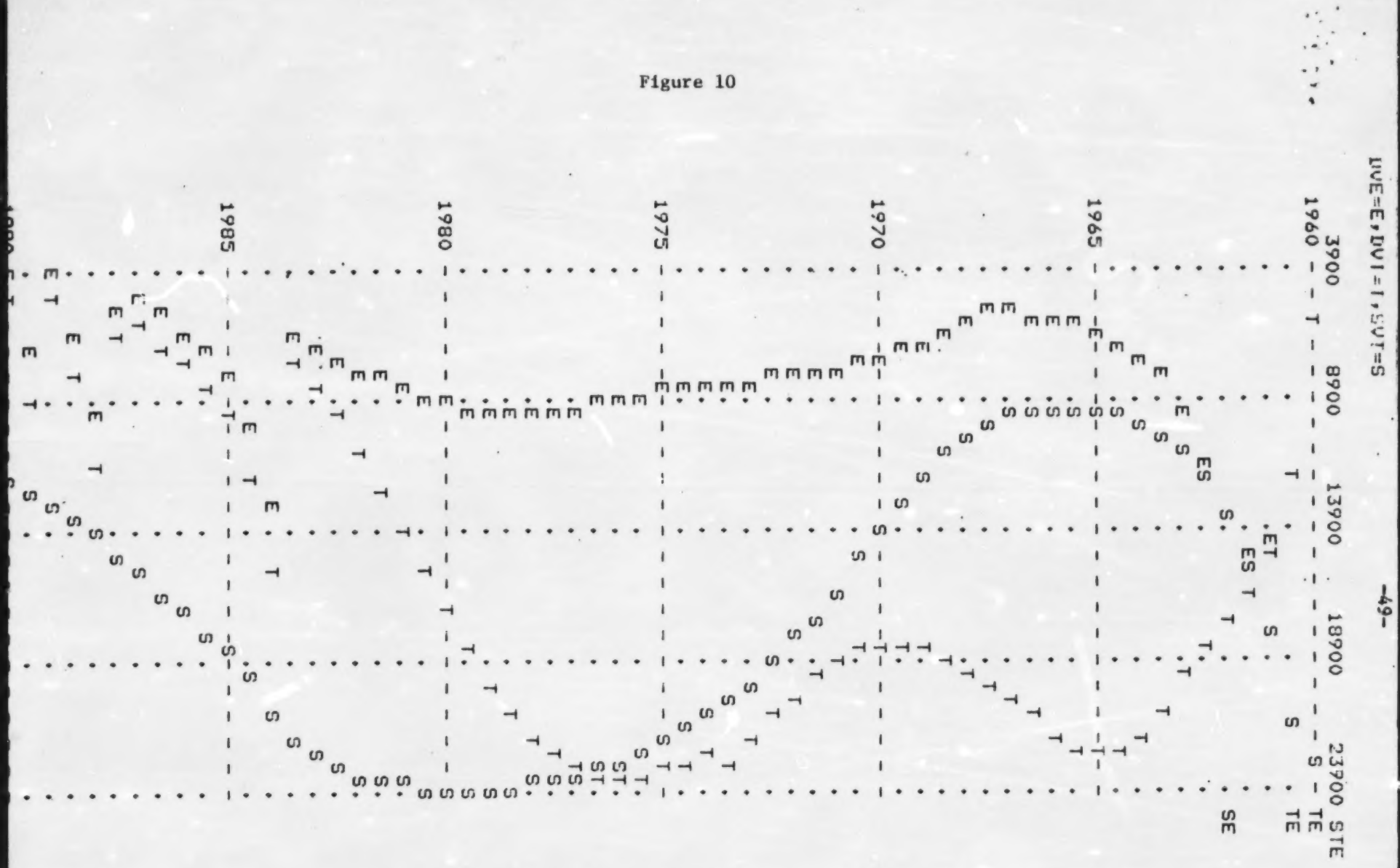
TS Teacher Surplus

demand) that lags slightly behind historical trends in the 1970's. For that reason, a second model run was performed, boosting employment effects on vocational enrollment. The result is an increase in enrollment to a point roughly tracking historical levels in the 1970's. But, importantly, the pattern of rising demand, followed by decline, still characterizes model putput over the entire period. Figure 10 shows the same pattern of desired teacher hiring lagging behind actual hires in the 1960's and 1970's but catching up in the 1980's. Figure 11 shows enrollments in high school and postsecondary vocational education peaking at higher levels around 1980 than the Base Run, but then falling back to about 1970 levels by 1990.

3.3.3 Conclusions: Model Runs. The model testing to date illuminates the degree to which supply/demand behavior, in general, in the education system is driven by demography. Further tests which change assumptions about employment levels might be interesting and useful, but the overall pattern of enrollments and teacher demand is unlikely to change. That may have serious implications for available vocationally trained workers — to the extent the economy actually relies on vocational education to occupationally prepare workers.

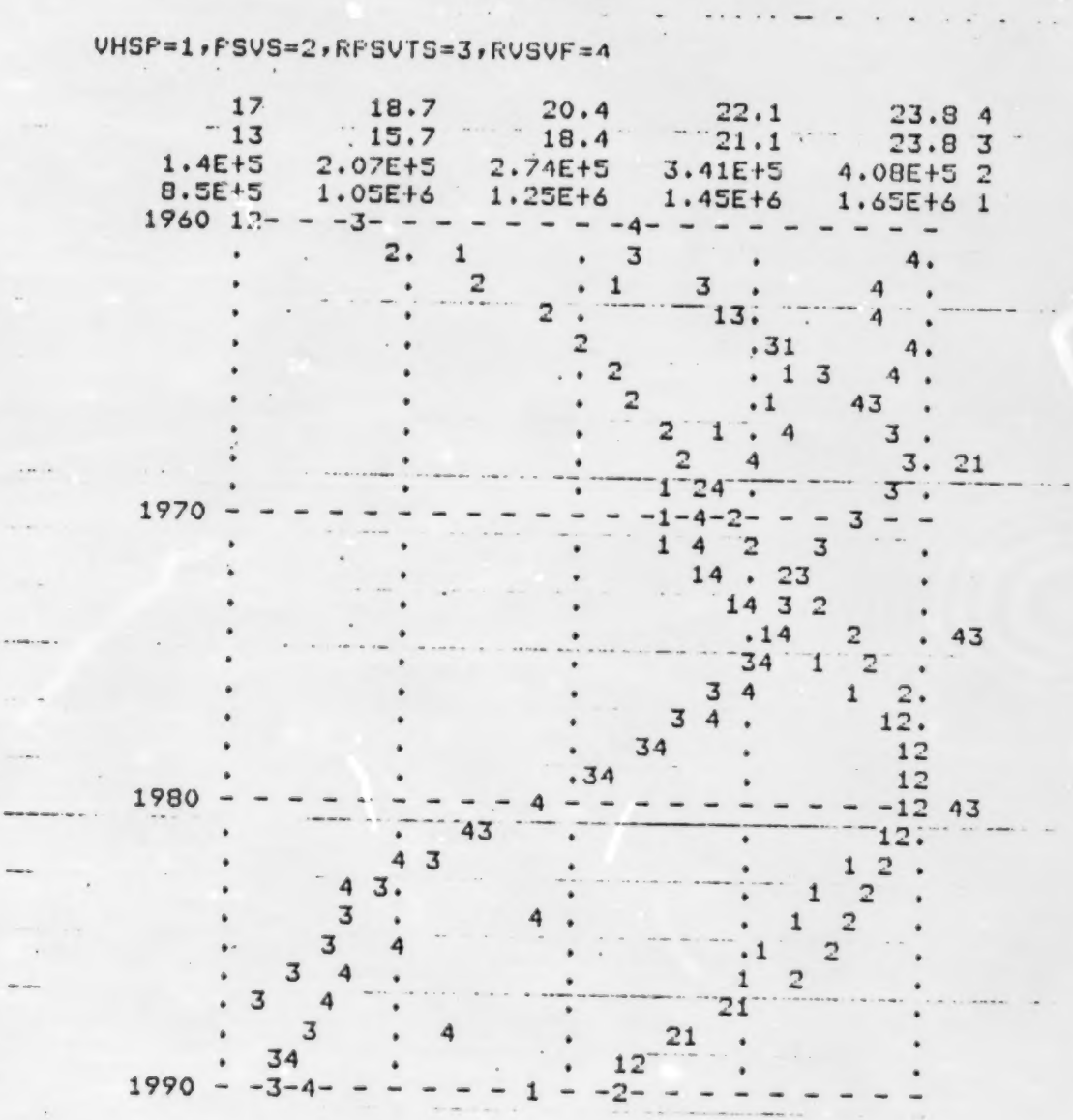
It is very important to note that the model does not attempt to simulate variability within vocational education. One can only speculate that shortages and surpluses in some occupational areas will continue. In addition, adult vocational education supply/demand considerations may change the picture completely. A separate modeling effort is probably required for each of these presently unconsidered areas. But, based on the work to date, in so far as the secondary and postsecondary system are concerned, on the whole, no serious shortages of vocational instructors would be expected through this decade and into the next. However, that merely reflects the modeler's assumptions about vocational training. National policy might change those assumptions. For example, it is conceivable that all non-academic high school students might be enrolled full-time in occupational training programs. If that were the case, enrollments would rise from the 1978 level of 15.5% of all high school students to about 50% of all high school students -- in

Figure 10



DVE Demand for Vocational Educators (Actual Hire Rate)
DVT Desired Vocational Teachers (Based on S/T Ratio)
SVT Supply of Vocational Teachers

Figure 11



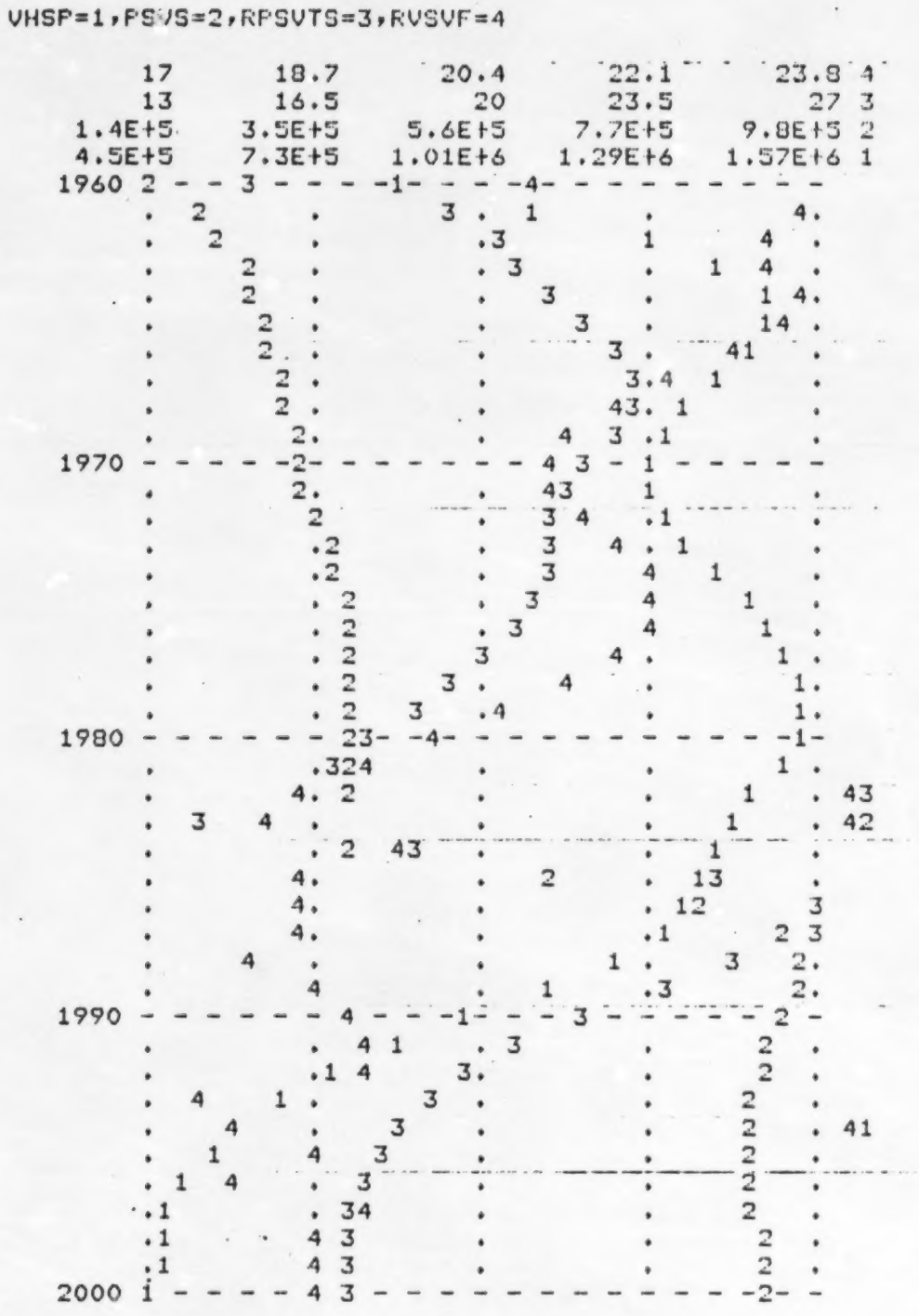
VHSP Vocational High School Population
PSVS Postsecondary Vocational Students
RPSVTS Ratio of Postsecondary Vocational Students to Ratio
RVSVF Ratio of High School Vocational Students to Teachers

which case there would be severe shortages of vocational teachers (and, equal surpluses of general, special and academic teachers).

A major change in funding allocation might affect the system, as might a serious down turn or up turn in the economy. But, it would take a major and disruptive change in employment to create serious shortages of vocational instructors on the whole (although within fields, such as computer science, there are and would continue to be shortages of qualified instructors). Inasmuch as the fraction of vocational aid from federal sources is small to begin with, only a dramatic change in federal funding will affect the systems' supply/demand behavior. Much more likely is the contest between general, special and vocational education advocates at the local and state levels as the total pool of students shrinks in the 1980's. If the constraint on resources, now fixed by law in California and Massachusetts, spreads to a majority of states, vocational education resource growth, relative to total resources for education, is rendered less likely than even the model simulates. In that case, it may become imperative for the federal role to expand in order to meet labor market demands for vocationally trained workers.

As a final note we have simulated the expected result of reinstituting selective service (Figure 12). Initial testing suggests that the result would be to temporarily reduce demand at the postsecondary level, but then stimulate demand (assuming that all high school graduates who enter military service, but would have otherwise gone into postsecondary vocational training, then pursue vocational training after a delay of two years). The stimulus effect observed in these tentative tests is similar to the World War II effect on college enrollments -- a temporary reduction, followed by rapid increases after World War II and then settling back to a continuous trend line. Additional testing will be required to reach any firm conclusions about the effect of a selective service program.

Figure 12



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